National Aeronautics and Space Administration

2020 NASA Technology Taxonomy

TX1 Propulsion Systems

1.1 Chemical Space Propulsion
- Integrated Systems and Ancillary Technologies
- Earth Storable
- Cryogenic
- Solids
- Hybrids
- Gels
- Cold Gas
- Warm Gas

1.2 Electric Space Propulsion
- Integrated Systems and Ancillary Technologies
- Electrostatic
- Electromagnetic
- Electrothermal

1.3 Aero Propulsion
- Integrated Systems and Ancillary Technologies
- Turbine Based Combined Cycle
- Rocket Based Combined Cycle
- Pressure Gain Combustion
- Turbine Based Jet Engines
- Ramjet/Scramjet
- Reciprocating Internal Combustion
- All Electric Propulsion
- Hybrid Electric Systems
- Turboelectric Propulsion
- Engine Icing
- Alternative Low Carbon Jet Fuel

1.4 Advanced Propulsion
- Solar Sails
- Electromagnetic Tethers
- Nulcear Thermal Propulsion
- Other Advanced Propulsion Technologies

TX2 Flight Computing and Avionics

2.1 Avionics Component Technologies
- Radiation Hardened Extreme Environment Components and Implementations
- Electronic Packaging and Implementations
- High Performance Processors
- High Performance Memories
- High Performance Field Programmable Gate Arrays
- Radiation Hardened ASIC Technologies
- Point-of-Load Power Converters
- Wireless Avionics Technologies

2.2 Avionics Systems and Subsystems
- Spacecraft Command and Data Handling Systems
- Aircraft Avionics Systems
- Vision and Virtual/Augmented Reality Avionics
- Low Power Embedded Computer Systems
- High Speed Onboard Interconnects and Networks
- Data Acquisition Systems
- Data Reduction Hardware Systems
- Use of Advanced Commercial-off-the-Shelf (COTS) Components
- Hardware Enabling Secure Avionics

2.3 Avionics Tools, Models, and Analysis
- Electronics Development Tools
- Space Radiation Analysis and Modeling
- Avionics Reliability and Fault-Tolerance Analysis and Modeling
- Electromagnetic Environment Effects

TX3 Aerospace Power and Energy Storage

3.1 Power Generation and Energy Conversion
- Photovoltaic
- Heat Sources
- Static Energy Conversion
- Dynamic Energy Conversion
- Electrical Machines
- Other Advanced Concepts for Generating/ Converting Power

3.2 Energy Storage
- Electrochemical: Batteries
- Electrochemical: Fuel Cells
- Advanced Concepts for Energy Storage

3.3 Power Management and Distribution
- Management and Control
- Distribution and Transmission
- Electrical Power Conversion and Regulation
- Advanced Electronic Parts

TX4 Robotic Systems

4.1 Sensing and Perception
- Sensing for Robotic systems
- State Estimation
- Onboard Mapping and Data Analysis
- Object, Event, and Activity Recognition

4.2 Mobility
- Below-Surface Mobility
- Above-Surface Mobility
- Small-Body and Microgravity Mobility
- Surface Mobility
- Robot Navigation and Path Planning
- Collaborative Mobility

4.3 Manipulation
- Dexterous Manipulation
- Grappling Technologies
- Contact Dynamics Modeling
- Sample Acquisition and Handling

4.4 Human-Robot Interaction
- Multi-Modal and Proximate Interaction
- Distributed Collaboration and Coordination
- Remote Interaction

4.5 Autonomous Rendezvous and Docking
- Relative Navigation Sensors
- Rendezvous and Docking Algorithms
- Rendezvous, Proximity Operations, and Capture (RPOC) Flight and Ground Systems
- Capture Sensors
- Capture Mechanisms and Fixtures
- Robot Control for Vehicle Capture and Berthing
- Modeling, Simulation, Analysis, and Test of Rendezvous, Proximity Operations, and Capture

4.6 Robotics Integration
- Modularity, Commonality and Interfaces
- Modeling and Simulation for Robots
- Robot Software

TX5 Communications, Navigation, and Orbital Debris Tracking and Characterization Systems

5.1 Optical Communications
- Detector Development
- Large Apertures
- Lasers
- Positioning, Acquisition, and Tracking
- Atmospheric Mitigation
- Optimetrics
- Innovative Signal Modulations

5.2 Radio Frequency
- Spectrum-Efficiency
- Power-Efficiency
- Atmospheric Characterization and Mitigation
- Flight and Ground Systems
- Earth Launch and Re-Entry Communications
- Innovative Antennas
- Innovative RF Technologies
- Antennas

5.3 Internetworking
- Disruption Tolerant Networking
- Adaptive Network Topology
- Information Assurance
- Integrated Network Management

5.4 Network Provided Position, Navigation, and Timing
- Timekeeping and Time Distribution
- Revolutionary PNT Technologies

5.5 Revolutionary Communication Technologies
- Cognitive Networking
- Quantum Communications
- Hybrid Radio and Optical Technologies

5.6 Networking and Ground Based Orbital Debris Tracking and Management Communication
- Orbital Debris Tracking
- Orbital Debris Characterization
- Orbital Debris Mitigation
- Orbital Debris Monitoring Software

5.7 Acoustic Communication

TX6 Human Health, Life Support, and Habitation Systems

6.1 Environmental Control and Life Support Systems and Habitation Systems
- Atmospheric Revitalization
- Water Recovery and Management
- Waste Management
- Habitation Systems
- ECLSS Modeling and Simulation Tools

6.2 Extravehicular Activity Systems
- Pressure Garment
- Portable Life Support System
- Informatics and Decision Support Systems
- Decompression Sickness Mitigation

6.3 Human Health and Performance
- Medical Diagnosis and Prognosis
- Prevention and Countermeasures
- Behavioral Health and Performance
- Contact-less/Wearable Human Health and Performance Monitoring
- Food Production, Processing, and Preservation
- Long Duration Health
- System Transformative Health and Performance Concepts

6.4 Environmental Monitoring, Safety, and Emergency Response
- Sensors: Air, Water, Microbial, and Acoustic
- Fire: Detection, Suppression, and Recovery
- Protective Clothing and Breathing
- Remediation

6.5 Radiation
- Radiation Transport and Risk Modeling
- Radiation Mitigation and Biological Countermeasures
- Protection Systems
- Space Weather Prediction
- Monitoring Technology

6.6 Human Systems Integration
- Human Factors Engineering
- Training
- Habitability and Environment
- Operations Effectiveness
- Integrated Systems Safety
- Maintainability and Supportability

TX7 Exploration Destination Systems

7.1 In-Situ Resource Utilization
- Destination Reconnaissance and Resource Assessment
- Resource Acquisition, Isolation, and Preparation
- Resource Processing for Production of Mission Consumables
- Resource Processing for Production of Manufacturing, Construction, and Energy Storage Feedstock Materials

7.2 Mission Infrastructure, Sustainability, and Supportability
- Logistics Management
- In-Situ Manufacturing, Maintenance, and Repair
- Surface Construction and Assembly
- Micro-gravity Construction and Assembly
- Particulate Contamination Prevention and Mitigation

7.3 Mission Operations and Safety
- Mission Planning and Design
- Integrated Flight Operations Systems
- Training
- Integrated Risk Assessment Tools
- Planetary Protection

TX8 Sensors and Instruments

8.1 Remote Sensing Instruments and Sensors
- Detectors and Focal Planes
- Electronics
- Optical Components
- Microwave, Millimeter-, and Submillimeter-Waves
- Lasers
- Cryogenic/Thermal

8.2 Observatories
- Mirror Systems
- Structures and Antennas
- Distributed Aperture

8.3 In-Situ Instruments and Sensors
- Field and Particle Detectors
- Atomic and Molecular Species Assessment
- Sample Handling
- Environment Sensors
- Electromagnetic Wave Based Sensors
- Extreme Environments Related to Critical System Health Management

TX9 Entry, Descent, and Landing

9.1 Aeroassist and Atmospheric Entry
- Thermal Protection Systems
- Hypersonic Decelerators
- Passive Reentry Systems for Smallsats

9.2 Descent
- Aerodynamic Decelerators
- Supersonic Retro-Propulsion

9.3 Landing
- Touchdown Systems
- Propulsion Systems

9.4 Vehicle Systems
- Architecture Design and Analysis
- Separation Systems
- System Integration and Analysis for EDL
- Atmosphere and Surface Characterization
- Modeling and Simulation for EDL
- Instrumentation and Health Monitoring for EDL
- GN&C for EDL

TX10 Autonomous Systems

10.1 Situational and Self Awareness
- Sensing and Perception for Autonomous Systems
- State Estimation and Monitoring
- Knowledge and Model Building
- Hazard Assessment
- Event and Trend Identification
- Anomaly Detection

10.2 Reasoning and Acting
- Mission Planning and Scheduling
- Activity and Resource Planning and Scheduling
- Motion Planning
- Execution and Control
- Fault Diagnosis and Prognosis
- Fault Response
- Learning and Adapting

10.3 Collaboration and Interaction
- Joint Knowledge and Understanding
- Behavior and Intent Prediction
- Goal and Task Negotiation
- Operational Trust Building

10.4 Engineering and Integrity
- Verification and Validation of Autonomous Systems
- Test and Evaluation of Autonomous Systems
- Operational Assurance of Autonomous Systems
- Modeling and Simulation of Autonomous Systems
- Architecture and Design of Autonomous Systems

TX11 Software, Modeling, Simulation, and Information Processing

11.1 Software Development, Engineering, and Integrity
- Tools and Methodologies for Software Design and Development
- Verification and Validation of Software Systems
- Test and Evaluation
- Operational Assurance
- Architecture and Design of Software Systems
- Real-Time Software
- Frameworks, Languages, Tools, and Standards
- Software Analysis and Design Tools
- Software Cyber Security

11.2 Modeling
- Software Modeling and Model Checking
- Integrated Hardware and Software Modeling
- Human-System Performance Modeling
- Science Modeling

11.3 Simulation
- Distributed Simulation
- Integrated System Lifecycle Simulation
- Model-Based Systems Engineering (MBSE)
- Simulation-Based Training and Decision Support Systems
- Exascale Simulation
- Uncertainty Quantification and Non-Deterministic Simulation Methods
- Multiscale, Multiphysics, and Multifidelity Simulation

11.4 Information Processing
- Science, Engineering, and Mission Data Lifecycle
- Intelligent Data Understanding
- Semantic Technologies
- Collaborative Science and Engineering
- Cyber Infrastructure
- Cyber Security
- Digital Assistant
- Edge Computing

11.5 Mission Architecture, Systems Analysis, and Concept Development
- Tools and Methodologies for Defining Mission Architectures or Mission Design
- Tools and Methodologies for Performing Systems Analysis
- Tools and Methodologies for Vehicle or Concept Definition Activities

11.6 Ground Computing
- Exascale Supercomputer
- Automated Exascale Software Development Toolset
- Exascale Supercomputer File System
- Quantum Computer
- Public Cloud Supercomputer
- Cognitive Computer
- High Performance Data Analytics Platform
- Cloud Computing

TX12 Materials, Structures, Mechanical Systems, and Manufacturing

12.1 Materials
- Lightweight Structural Materials
- Computational Materials
- Flexible Material Systems
- Materials for Extreme Environments
- Coatings
- Materials for Electrical Power Generation, Energy Storage, Power Distribution, and Electrical Machines
- Special Materials
- Smart Materials

12.2 Structures
- Lightweight Concepts
- Design and Certification Methods
- Reliability and Sustainment
- Tests, Tools and Methods
- Innovative, Multifunctional Concepts

12.3 Mechanical Systems
- Deployables, Docking, and Interfaces
- Electro-Mechanical, Mechanical, and Micromechanisms
- Design and Analysis Tools and Methods
- Reliability, Life Assessment, and Health Monitoring
- Certification Methods
- Mechanical Drive Systems
- Mechanism Life Extension Systems
- Docking and Berthing Mechanisms and Fixtures

12.4 Manufacturing
- Manufacturing Processes
- Intelligent Integrated Manufacturing
- Electronics and Optics Manufacturing Process
- Sustainable Manufacturing
- Nondestructive Evaluation and Sensors
- Repurpose Processes

12.5 Structural Dynamics
- Loads and Vibration
- Vibroacoustics
- Shock and Impact
- Test, Tools, and Methods

TX13 Ground, Test, and Surface Systems

13.1 Infrastructure Optimization
- Natural and Induced Environment Characterization and Mitigation
- Launch/Test/Ops Site Management
- Commodity Recovery
- Propellant Production, Storage, and Transfer
- Ground and Surface Logistics
- Test, Operations, and Systems Safety
- Impact/Damage/Radiation-Resistant Systems

13.2 Test and Qualification
- Mechanical/Structural Integrity Testing
- Propulsion, Exhaust, and Propellant Management
- NDI, Evaluation, and Root Cause Analysis
- Verification and Validation of Ground, Test, and Surface Systems
- Flight and Ground Testing Methodologies
- Advanced Life-Cycle Testing Techniques
- Test Instruments and Sensors
- Environment Testing

13.3 Assembly, Integration, and Launch
- Offline Element Processing
- Vehicle and Payload Assembly and Integration
- Launch, Recovery, and Reutilization

13.4 Mission Success Technologies
- Mission Planning
- Team Preparedness and Training
- High-Fidelity Simulation and Visualization
- Autonomous, Real-Time Command and Control
- Operations, Health, and Maintenance for Ground and Surface Systems
- Ground Analogs for Space/Surface Systems

TX14 Thermal Management Systems

14.1 Cryogenic Systems
- In-Space Propellant Storage and Utilization
- Launch Vehicle Propellant
- Thermal Conditioning for Sensors, Instruments, and High Efficiency Electric Motors
- Ground Testing and Operations
- Cryogenic Analysis, Safety, and Properties

14.2 Thermal Control Components and Systems
- Heat Acquisition
- Heat Transport
- Heat Rejection and Storage
- Insulation and Interfaces
- Thermal Control Analysis
- Heating Systems
- Verification and Validation of Thermal Management Systems
- Measurement and Control

14.3 Thermal Protection Components and Systems
- Thermal Protection Materials
- Thermal Protection Systems
- Thermal Protection Analysis
- Thermal Protection System Testing
- Thermal Protection System Instrumentation

TX15 Flight Vehicle Systems

15.1 Aerosciences
- Aerodynamics
- Aerothermodynamics
- Aeroelasticity
- Aeroacoustics
- Propulsion Flowpath and Interactions
- Advanced Atmospheric Flight Vehicles
- Computational Fluid Dynamics (CFD) Technologies
- Ground and Flight Test Technologies

15.2 Flight Mechanics
- Trajectory Design and Analysis
- Flight Performance and Analysis
- Flight Mechanics Testing and Flight Operations
- Modeling and Simulation for Flight

TX16 Air Traffic Management and Range Tracking Systems

16.1 Safe All Vehicle Access

16.2 Weather/Environment

16.3 Traffic Management Concepts

16.4 Architectures and Infrastructure

16.5 Range Tracking, Surveillance, and Flight Safety Technologies

16.6 Integrated Modeling, Simulation, and Testing

TX17 Guidance, Navigation, and Control

17.1 Guidance and Targeting Algorithms
- Guidance Algorithms
- Targeting Algorithms

17.2 Navigation Technologies
- Onboard Navigation Algorithms
- Ground-Based Navigation Algorithms
- Navigation Sensors
- Relative Navigation Aids
- Rendezvous, Proximity Operations, and Capture Sensor Processing and Prcoessors
- Rendezvous, Proximity Operations, and Capture Trajectory Design and Orbit Determination

17.3 Control Technologies
- Onboard Maneuvering/Pointing/Stabilization/ Flight Control Algorithms
- Dynamics Analysis, Modeling, and Simulation Tools
- Ground-Based Maneuvering/Pointing/Stabilization/ Flight
- Control Algorithms
- Control Force/Torque Actuators
- GN&C Actuators for Six Degrees of Freedom (6DOF) Spacecraft Control During Rendezvous, Proximity Operations, and Capture

17.4 Attitude Estimation Technologies
- Onboard/Attitude Rate Estimation Algorithms
- Ground-Based Attitude Determination/Reconstruction Algorithm Development
- Attitude Estimation Sensors

17.5 GNC Systems Engineering Technologies
- GN&C System Architectures, Requirements, and Specifications
- GN&C Fault Management/Fault Tolerance/ Autonomy
- GN&C Verification and Validation Tools and Techniques
- GN&C Ground Testbeds/Test Facilities
- Vehicle Flight Dynamics and Mission Design Tools Techniques
- System Identification
- End-to-End Modeling and Simulation of GN&C Systems
- Flying/Handling Qualities
- Onbaord and Ground-Based Terrain and Object Simulation, Mapping, and Modeling Software

17.6 Technologies for Aircraft Trajectory Generation, Management, and Optimization for Airspace Operations
- Strategic Management of Air Vehicles
- Tactical Management of Air Vehicles

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